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Pharmaceutical Markets in the German Empire. Profits Between Risk, Altruism and Regulation

Axel C. Hüntelmann*

Abstract: »Pharma-Märkte im Deutschen Kaiserreich. Profite zwischen Risiko, Altruismus und Regulierung«. For the first time in August 1894, phials of anti-diphtheria serum went on sale in German pharmacies. Anti-diphtheria serum was a major therapeutic innovation in the treatment of a terrible infectious disease. The anti-diphtheria serum also signalled the evolution of new regulatory institutions, as well as new markets in industrially produced pharmaceuticals. The new serum therapy offered not only a cure for diphtheria and other fatal infectious diseases, but also promised high profits for the manufacturers who could stabilize the production process. It attracted the state's attention for a number of reasons: the ambiguous legal situation, the production of serum for the free market and the prospect of high profits for the serum industry, and finally the novelty of serum therapy itself and the lack of information about its long-term effects. Drawing on concepts from economic sociology, I will argue that the evolving serum market was formatted by state authorities from the very first moment. This regulation was not imposed by "the state" but negotiated among actors like state officials, medical and public health professionals, and serum producers.

Keywords: pharmaceutical market, anti-diphtheria serum, public health risk, state regulation of pharmaceuticals.

For the first time in August 1894, phials of anti-diphtheria serum produced by the Farbwerke vorm. Meister Lucius & Brüning in the town of Hoechst went on sale in German pharmacies. One month later, at the Eighth International Congress of Hygiene in Budapest, the scientific world was introduced to the new therapy against diphtheria and the serum was greeted as a great breakthrough in the treatment of a terrible disease.¹ The anti-diphtheria serum was a

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¹ For example: Émile Roux to Émile Duclaux, Head of the Pasteur Institute, 15.9.1894, Museum of the Pasteur Institute, fol. 11504. A report about the congress in *La semaine médicale*, 14 (Issue 51, 8.9.1894); *Le Bulletin Médical* (1894), pp. 827-829, 844-845, the paper of Roux given on the Congress on pp. 1165-1168. For Germany see several articles of German newspapers in the Bundesarchiv Berlin (Federal Archive, henceforth BA Berlin), R 86/1182; a report in the *Deutsche Medizinische Wochenschrift*, 20 (Issue 35-37, 1894), pp. 700-703, 715, 729-731; detailed and with a print of several talks given in Budapest in *Centralblatt für Bakteriologie und Parasitenkunde*, 16 (1894), pp. 737-742, 778-784,

major therapeutic innovation – celebrated as a milestone in bacteriology and a revolution in pharmacology² – at the end of the 19th century. Representing a new form of therapy, the innovation of anti-diphtheria serum marks the starting point for many other biological therapies. The anti-diphtheria serum also signalled the evolution of new regulatory institutions, as well as new markets in industrially produced pharmaceuticals.

Antitoxin was the therapeutic agent contained in the anti-diphtheria serum. The new serum therapy offered not only a cure for diphtheria and other fatal infectious diseases, but also promised high profits for the manufacturers who could stabilize the production process and produce the serum in large industrial quantities. Given that there was no patent on the anti-diphtheria serum and that research results were freely available in prominent medical publications, a health professional trained in bacteriology could reconstruct the experiments and produce serum without breaking the law. The new serum therapy attracted the state's attention for a number of reasons: the ambiguous legal situation, the production of serum for the free market and the prospect of high profits for the serum industry, the experience a few years earlier with tuberculin and the public health scandal it had triggered, and finally the novelty of serum therapy itself and the lack of information about its long-term effects. Thus, in hopes of minimizing public health risks, the state implemented and institutionalized a strict regime of control.

In his book on the *Architecture of Markets*, Neil Fligstein highlights the importance of governments to markets by investigating the sociology of market processes and the socio-political embeddedness of markets.³ Public infrastructure and institutions, social structures and social relations, or the legal system have a major influence on the free market – if they are not the premise for market society – by guaranteeing the functioning of markets. In order to define the “terrain of a sociology of markets”, Fligstein scrutinizes the relation between state and firms in the process of the production of markets and the dynamics by which markets are created, stabilized and transformed.⁴ This per-

822-826, 881-896, 908-914, 955-959, 960-965, 1013-1018, 1054-1058; and in the *Deutsche Vierteljahrsschrift für öffentliche Gesundheitspflege*, 27 (1895), pp. 209-276, 401-464.

² Cf. Hanspeter Mochmann/Werner Köhler, *Meilensteine der Bakteriologie. Von Entdeckungen und Entdeckern aus den Gründerjahren der Medizinischen Mikrobiologie*, Jena 1984; Heinz Schott (ed.), *Meilensteine der Medizin*, Dortmund 1996; Wolf-Dieter Müller-Jahncke/Christoph Friedrich/ Ulrich Meyer, *Arzneimittelgeschichte*, 2. ed., Stuttgart 2005; Ann S. Persson, *Smallpox, Syphilis and Salvation. Medical Breakthroughs that changed the World*, Wollombi 2009.

³ Cf. Neil Fligstein, *The Architecture of Markets. An Economic Sociology of Twentieth-First-Century Capitalist Societies*, Princeton 2001.

⁴ Cf. *Ibid.*, p. 3-23. Fligstein asks first for the social rules that must exist for markets to function, and the social structures that are necessary to produce stable markets (10 f.). Secondly, he investigates the “relation between states and firms in the production of markets” (11-13). Thirdly, he is looking for the social and – in opposition to this – the economic

spective is applied and discussed in the following article. With reference to Fligstein, I will argue that the evolving serum market was formatted by the state from the very first moment. Even after the serum market became stabilized and the forces of supply and demand seemed to be free from direct intervention like in the neo-classical market model, the market remained strictly regulated. This regulation was not imposed by “the state” but negotiated among actors like state officials, medical and public health professionals, and serum producers.⁵

In this article, I will sketch the framework of pharmaceutical markets in the German Empire, and focus on the evolving market of biologicals around 1900 (1). The years around the fin-de-siècle mark a turning point in the history of pharmaceuticals. After a review of the market organization of remedies up to the 1890s (2), I will examine why there was a need for state regulation (3) and how the process of regulation became stabilized and institutionalized by summarizing the further course of events after the anti-diphtheria serum had been introduced to the public in the summer of 1894. Shortly after the launching of anti-diphtheria serum, a state-run institution of serum regulation had been established (4). Thereafter I will frame the market and distinguish the demand side, the supply side, and the price and the product as essential elements of the market (5a-c). Finally, I will look forward to subsequent developments (6) and embed the evolving market for ‘biologicals’ in its historical context (7).

1. Actors of the Drug Market – (what are we talking about)

What does a market for drugs mean? And what meanings does the term “drug” include? From the perspective of sick people and suffering patients we are talking about pain-relieving substances or life-saving remedies, from the viewpoint of the practitioner we are talking about an object that gives him or her the power to cure ill-feeling persons. From the outlook of the practitioner, but also from the perspective of the apothecary and the pharmacologist drugs are scientific objects, or objects of knowledge. For practitioners, apothecaries and especially for the chemical industry drugs are also economic commodities that were produced and sold in pharmacies, offering prospective benefits. But drugs are not simple commodities, they are precarious matters, difficult to handle – im-

“view of what actors seek to do in markets” (13f.). Forthly, Fligstein takes into view the dynamics “by which the markets are created, attain stability, and are transformed” (14). Finally, he is asking for the “implications of market dynamics for the internal structuring of firms and labor markets” (14 f.).

⁵ The market is understood here as an arena of social action where coordination problems between the different market actors were levelled out. The structure of the market as a fundamental precondition for the market processes is discussed in Jens Beckert, *Die soziale Ordnung von Märkten*, in: idem et al. (eds.), *Märkte als soziale Strukturen*, Frankfurt/Main 2007, pp. 43-62.

proper use can be life-threatening – and their consumption often requires prior knowledge and expertise.⁶

From all different perspectives, the common meaning of “drugs” or “remedies” was fluid around 1900: homoeopathic substances, nutrition additives, cosmetics, vaccines and other biologicals like plant extracts and organ substances, over-the-counter and prescription medication.⁷ On the other side, the *Pharmacopeia Germanica* provided a detailed list of substances that were defined as “official” remedies and drugs (that were protected by the state). From the viewpoint of medical professionals and the medical scientific community, nostrums or secret and folk remedies were explicitly excluded from this officially sanctioned list of drugs (and so comprised another market altogether). Insofar the meaning of drug and remedy is framing a different market and different market actors. In this article, I will focus on the “official” drug market that includes all drugs and remedies that were seen as remedies by the medical (scientific) community and sanctioned by the state.

In accordance with studies on drug trajectories in the 20th century,⁸ we can identify several actors in this market: the consumer, which means the patient; the producer; the retailer namely (and only) apothecaries, and medical professionals. As the sale of pharmaceuticals as well as the education and apprenticeship of physicians and apothecaries was tightly regulated by the state, the public health administration represents a further group of actors. Within this field of actors I will focus on the evolving market of biologicals and especially bacterio- and serum therapeutics.

⁶ Cf. the anthology of Viola Balz/Alexander von Schwerin/Heiko Stoff/Bettina Wahrig (eds.), *Precarious Matters/Prekäre Stoffe. The History of Dangerous and Endangered Substances in the 19th and 20th century* (Preprint of the Max-Planck-Institute for the History of Science 356), Berlin 2008.

⁷ Cf. Wolfgang Schneider, *Geheimmittel und Spezialitäten. Sachwörterbuch zu ihrer Geschichte bis um 1900* (Lexikon zur Arzneimittelgeschichte 4), Frankfurt/Main 1969; Elmar Ernst, *Das “industrielle” Geheimmittel und seine Werbung. Arzneifertigwaren in der zweiten Hälfte des 19. Jahrhunderts in Deutschland*, Würzburg 1975; Wayne Bethard, *Lotions, Potions, and Deadly Elixirs. Frontier Medicine in America*, Lanham 2004; Stuart Anderson, *Making Medicine. A brief History of Pharmacy and Pharmaceuticals*, London 2005; Erika Hickel, *Die Arzneimittel in der Geschichte. Trost und Täuschung, Heil und Handelsware*, Nordhausen 2008.

⁸ Cf. Jean-Paul Gaudillière, *Introduction. Drug Trajectories*, in: *Studies in the History and Philosophy of Biology and Biomedical Sciences* 36 (2005), pp. 603–611; Jean-Paul Gaudillière/Volker Hess (eds.), *Ways of Regulating. Therapeutic Agents between Plants, Shops, and Consulting Rooms* (Preprint of the Max-Planck-Institute for the History of Science 363), Berlin 2008; see also <www.drughistories.eu>.

2. The Pharmaceutical Market Up to the 1890s

The “production” of anti-diphtheria serum was innovative in two respects. Launching the serum onto the pharmaceutical market represented a new type of drug and a new therapeutic principle. Previously, the preparation of pharmaceuticals lay entirely in the hands of the pharmacists, making them the arbiters of quality control and legislation. Pharmacists – whose training and title were strictly regulated – mixed the preparations in their apothecaries, where drugs were produced only in small quantities. The *Pharmacopoeia* regulated only the degree of purity of the remedy’s ingredients. Apothecaries had to test their purity, harmlessness, and potency before bringing them to market, i.e. selling them in their pharmacies. Since the late 1880s, medications like Aspirin and Antipyrin were produced in large quantities in industrialized production plants and offered as finished products in tablet form.⁹ With the rising pharmaceutical industry, it became difficult for apothecaries to analyze the ingredients, meaning that they could no longer guarantee the quality of the tablets or pills sold in their pharmacies.

Quality control led to a second novelty. The serum was a living agent of sorts – an extract drawn from a living organism that could be of variable quality, depending on the organism that produced it. To find a universal standard, a serum unit had to be defined because the physicians in private practice and in the hospitals needed criteria for gauging serum use. Furthermore a unit of value was necessary to compare the potency of different sera on the pharmaceutical market. The so-called evaluation of serum transformed an undefined, imponderable effect into a quantifiable and comparable value. The evaluation of serum determined its “value”, indicating the impact and the potency of anti-diphtheria serum that had been incorporated into an organism. One spoke of antitoxin- or immunisation units. One hundred immunisation units were defined as a minimum of curative value. The process was very complicated; and an apothecary could barely handle it. In the mid-1890s, serum with a certain amount of immunisation units was mixed with an equivalent standard toxin (that again was fixed as the lethal dosis required to kill a guinea pig of approx. 250-300 grams within four days). The mixture of standard toxin and serum was injected into a guinea pig.¹⁰ The curative value of serum was defined, when the guinea pig showed no reactions on its injected side or only slight reactions that

⁹ Cf. Erika Hickel, *Arzneimittel-Standardisierung im 19. Jahrhundert in den Pharmakopöen Deutschlands, Frankreichs, Großbritanniens und der Vereinigten Staaten von Amerika*, Darmstadt 1973; Wolfgang Wimmer, “Wir haben fast immer was Neues”. *Gesundheitswesen und Innovation der Pharma-Industrie in Deutschland, 1880-1935*, Berlin 1994.

¹⁰ Cf. Robert Koch/Emil Behring/Paul Ehrlich/Stabsarzt Dr. Weisser, *Vorschläge, die Prüfung des Diphtherieserums und seinen Vertrieb betreffend*, November 1894, BA Berlin, R 86/1646; Richard Otto, *Die staatliche Prüfung der Heilsera* (Arbeiten aus dem Königlichen Institut für experimentelle Therapie zu Frankfurt a. M., Vol. 2), Jena 1906, pp. 39f.

faded away within four days.¹¹ In practice, producers needed regulation, standardization and specialization to figure out the value of a serum. In response to this need, the process was institutionalized.

3. Need for Regulation?

From the public health administration's point of view there were several aspects that justified – or rather: necessitated – a regulative intervention. As mentioned above, the research results on the new serum therapy were published in several medical periodicals. The articles were freely available and so in August 1894 it was in principle possible for a well-informed microbiologist to reconstruct the production process and to produce the serum. Moreover, there was neither a patent covering the production and use of serum therapy nor specific trademark protections. In general, in Germany the patent legislation applied to chemicals was adopted in 1891 for pharmaceuticals, meaning that only processes and not products could be protected.¹² Thus anybody could copy the serum (as a product). One would only need to vary the production procedure to skirt legal problems. Just a few years earlier in Berlin, Koch's unsuccessful treatment for tuberculosis, Tuberculin, had triggered a scandal that continued to rock the public health administration. In the tuberculin case, initial optimism had quickly turned sour, while officials watched impotently from the sidelines, not knowing how or whether to intervene.¹³ Anti-diphtheria serum had been obtained from the blood of animals – mainly horses. The novelty of serum therapy and a lack of information concerning its long-term effects, as well as the prospect of high profits in the serum industry prompted high-ranking government officials into legislative action. Nevertheless, the principle aim was probably to minimize biopolitical risks and to avoid any scandal arising from unscrupulous firms selling ineffective or impure serum.

¹¹ Cf. Ehrlich, *Controle* 1896. The different drafts for the test procedure in the Archive of the Paul Ehrlich Institute (henceforth APEI), Dept. Va, No. 1, Vol. 1. Already in 1897 the method of evaluation changed due to problems resulting from variances and the sinking poisonousness of the standard toxin. Since mid-1897, the scale basis was a dried and vacuum sealed standard serum, cf. Axel C. Hüntelmann, The dynamics of "Wertbestimmung", in: *Science in Context* 21 (2008), pp. 229-252.

¹² Cf. Wimmer, *Gesundheitswesen*, pp. 85-101; Margrit Seckelmann, *Industrialisierung, Internationalisierung und Patentrecht im Deutschen Reich, 1871-1914*, Frankfurt/Main 2006.

¹³ Christoph Gradmann, "Ein Fehlschlag und seine Folgen. Robert Kochs Tuberkulin und die Gründung des Instituts für Infektionskrankheiten in Berlin 1891", in idem/Thomas Schlich (eds.), *Strategien der Kausalität. Konzepte der Krankheitsverursachung im 19. und 20. Jahrhundert* (Pfaffenweiler, 1999), pp. 29-52, in particular p. 36-38; idem, *Krankheit im Labor. Robert Koch und die medizinische Bakteriologie*, Göttingen 2005.

4. Institutionalisation of Regulation

In early November 1894 a conference was organized by the Imperial Health Office – the highest medical authority in the German Empire – bringing together medical officials from the Prussian Ministry for Cultural Affairs, representatives of the Federal states, the Imperial Health Office, and scientists from the Prussian Institute for Infectious Diseases, like Paul Ehrlich, Robert Koch, and Emil Behring. Later on, representatives of the pharmaceutical industry were also included in the discussion. The participants at this conference discussed the regulation of the new serum therapy and the need to protect the public against impure or ineffective serum.¹⁴

Interestingly, one of the proposals for state regulation took the Pasteur Institute as their model, proposing an Imperial institute to produce and distribute the serum.¹⁵ The production of anti-diphtheria serum was financed in France by private donations and attended by a nation-wide public campaign. In the German health administration, however, the idea of a state-run institute was only raised by government medical officials as a threat to the serum producers.¹⁶ Furthermore, there was also a call for donations in the name of the Empress to found such a state-run institute for serum production,¹⁷ along with several other appeals, especially in the early months, for funds to pay for free serum for the poor.¹⁸

Between November 1894 and February 1895 a series of meetings gave rise to draft legislation covering serum production, distribution and sale. In accordance with an imperial decree from January 1890, the diphtheria serum could

¹⁴ Minutes of the meeting from 3rd and 5th of November 1894 in BA Berlin, R 86/1646. For background information regarding the importance of the conference see Heinz Zeiss/Richard Bieling, Emil von Behring. Gestalt und Werk (Berlin, 1941), pp. 153-157.

¹⁵ Cf. the discussions on a meeting on October 19th in the Imperial Health Office, BA Berlin, R 86/1646; and the minutes of a meeting at the Prussian Ministry for Cultural Affairs on October 24th 1894, Geheimes Staatsarchiv Berlin (henceforth GStA PK), HA 1, Rep. 76 VIII B, No. 3747; undated report from B. Fraenkel about the distribution of diphtheria serum in France, *ibid*; see also Carola Throm, *Das Diphtherieserum. Ein neues Therapieprinzip, seine Entwicklung und Markteinführung*, Darmstadt 1995, p. 71.

¹⁶ Cf. Althoff an Behring, 15.11.1894, Behring-Archiv Marburg, folder 8-01: Correspondence Althoff, Doc. 1; the head of the Imperial Health Office, Carl Koehler, about Althoff's idea in a letter to Josef von Kerschensteiner, extraordinary member of the Imperial Health Office and privy council in the Bavarian Ministry of the Interior, 27.11.1894, BA Berlin, R 86/1646; plans to found a state-run institute of serum production are reported in the *Berliner Tageblatt*, 26.2.1908.

¹⁷ Cf. the appeal for funds in the name of the Empress for a German Institute for serum production, BA Berlin, R 86/1646.

¹⁸ The Kaiserin-Friedrich-Hospital in Berlin received 30,000 Marks for this cause, and a call for donations from the *Lokal-Anzeiger* in Berlin also raised some money, cf. the donation of 30,000 Marks the letter of Rudolf Virchow to an unnamed privy council, 17.10.1894, GStA PK, HA 1, Rep. 76 VIII B, No. 3747. The "Appeal to all philanthropists" for funds to buy serum for the poor by the newspaper owner August Scherl in October 1894, *ibid*.

only be sold in pharmacies, thus ensuring that the distribution of diphtheria serum was limited to medical specialists. Following a Federal resolution of July 1891, a prescription was required for the anti-diphtheria serum and the serum was inscribed in the *Pharmacopoeia Germanica* as *serum antidiphthericum*.¹⁹ In the absence of empirical knowledge about the action of the serum, officials decided to link its introduction onto the market with the compilation of medical statistics to prove the effectiveness of the new therapy.²⁰

The most important point in the German scheme was the state control of the production, distribution, and the commercial exploitation of the serum. Only a trained expert could determine the potency of the serum, and the mass production of the serum reinforced this state of affairs, with industrial laboratories rather than pharmacies becoming sites of both production and quality control.²¹

The surveillance of serum production combined centralized and local elements and involved not only the monitoring of the production process, but also the use of a state institute for serum control. In every production plant the process was permanently monitored by a medical officer, paid by the producer, but answerable to the state in the form of the Prussian Ministry for Cultural Affairs or the district president. In addition, the serum was tested for purity as well as being evaluated and certified centrally at the Serological Institute founded in February 1895.²² There were also strict regulations concerning the handling and packaging prior to distribution, and the sale price was regulated, with special tariffs for social insurance organizations, welfare institutions, and hospitals.

¹⁹ Reichsgesetzblatt 1895, p. 1.

²⁰ Cf. the minutes of the meeting from 3rd and 5th of November 1894 in BA Berlin, R 86/1646. The results of the statistics were published as "Ergebnisse der Sammelforschung über das Diphtherieheilserum für die Zeit vom April 1895 bis März 1896" and sent to every library in the German Empire and to several institutions, cf. BA Berlin, R 86/1646. A summary was published in *Arbeiten aus dem Kaiserlichen Gesundheitsamt*, 13 (1897), pp. 254-292. The regulation of anti-diphtheria serum is described in detail in Axel C. Hüntelmann, *Hygiene im Namen des Staates. Das Reichsgesundheitsamt 1876-1933*, Göttingen 2008, ch. 3.3.

²¹ Cf. Hickel, *Arzneimittel-Standardisierung*; Wimmer, *Gesundheitswesen*. The aim of the control was the reduction of sources of error. With the industrialization process it was easier to control a few producers than to control thousands of pharmacies.

²² The control station for diphtheria serum was first housed in the Institute for Infectious Diseases, headed by Robert Koch, before it became independent 1896 as Institute of Serum Research and Serum Testing. After the institute moved to Frankfurt on Main in 1899 it was renamed as Institute of experimental Therapy, for a short history see Wilhelm Kollé (ed.), *Das Staatsinstitut für experimentelle Therapie und das Chemo-therapeutische Forschungsinstitut "Georg Speyer-Haus" in Frankfurt a. M. Ihre Geschichte, Organisation und ihre Arbeitsgebiete*, in *Arbeiten aus dem Staatsinstitut für experimentelle Therapie und dem Georg Speyer-Hause zu Frankfurt a. M.* 16 (1926), p. 1-67; Axel C. Hüntelmann, *Eigenartige Sonderstellung in der Welt. Das Königlich Preussische Institut für Experimentelle Therapie und das Georg Speyer-Haus im Deutschen Kaiserreich*, in: Axel C. Hüntelmann/Michael C. Schneider (eds.), *Jenseits von Humboldt. Wissenschaft im Staat, 1850-1990*, Frankfurt/Main 2010, pp. 189-215.

Finally, the producers guaranteed the recall of phials from pharmacies after two years or if the serum was ineffective or impure. Within a few months, the legislation was implemented and the state institute for serum control established.²³ Thus, after April 1st 1895, only state-certified serum could be sold in Germany.

5a. Framing the Market – Demanding Consumer

The state regulation of serum production and distribution had an enormous impact on the serum market – or to be more precise: serum regulation constituted and regulated the serum market. The demand for (German) anti-diphtheria serum rapidly increased,²⁴ but identifying the consumer and distinguishing between patients and physicians was difficult. According to the federal resolution of 1891, patients needed a medical prescription to obtain the serum. As a result, the producers marketed their product to the physicians prescribing the remedy, not to the patient as the end-consumer. This corresponds with studies on the medicalization of the patient, who was not considered as a mature end-consumer.²⁵ Around 1900 and in the context of pharmaceuticals, marketing should be understood as “bringing the product to the market” in a neutral sense and not mixed up with propaganda. At the turn of the century, the chemical companies did not have had a propaganda department for their pharmaceutical products²⁶ and beyond this, the promotion of medical

²³ See the minutes of the meeting from the 17.12.1894, 17.1.1895 and 1.2.1895 and the correspondence between the participants of the meetings in BA Berlin, R 86/1646; GStA PK, HA 1, Rep. 76 VIII B, No. 3747; about the foundation of the Serological Institute see GStA PK, HA 1, Rep. 76 Vc, Sekt. 1, Tit. XI, part II, No. 18, vol. 1.

²⁴ Evidenced by the rising turnover in serum phials, the amount of serum certified by state-run institutes, and company profits, cf. the turnover Throm, Diphtherieserum; the rising quantity of serum is listed in the files of the Institute of Serum Research and Serum Testing GStA PK, HA 1, Rep. 76 Vc, Sekt. 1, Tit. XI, part II, No. 18, vol. 1.

²⁵ For the medicalization of patients see i. e. studies in the 1980s and 1990s like Claudia Huerkamp, *Der Aufstieg der Ärzte im 19. Jahrhundert. Vom gelehrten Stand zum professionellen Experten: Das Beispiel Preußens*, Göttingen 1985; Francisca Loetz, *Vom Kranken zum Patienten. “Medikalisierung” und medizinische Vergesellschaftung am Beispiel Badens 1750-1850*, Stuttgart 1993; or as an overview: idem, “Medikalisierung” in Frankreich, Großbritannien und Deutschland, 1750-1850. Ansätze, Ergebnisse und Perspektiven der Forschung, in: Wolfgang E. Eckart/Robert Jütte (eds.), *Das europäische Gesundheitssystem. Gemeinsamkeiten und Unterschiede in historischer Perspektive*, Stuttgart 1994, pp. 123-161.

²⁶ There is only little research on the history of marketing of pharmaceuticals, cf. for Britain: Takahiro Ueyama, *Health in the marketplace. Professionalism, therapeutic desires, and medical commodification in late-Victorian London*, Palo Alto 2010; for Germany: Jochen Binder, *Zwischen Standesrecht und Marktwirtschaft. Ärztliche Werbung zu Beginn des 20. Jahrhunderts im deutsch-englischen Vergleich*, Frankfurt/Main 2000. Cf. also papers of Frank Huisman (for the Dutch market), María Jesús Santesmass (distributing Penicillin in Spain) and Sergio Sismondo in Viviane Quirke/Judy Slinn (eds.), *Perspectives on 20th-century pharmaceuticals*, Frankfurt/Main 2010. On the early marketing of Salvarsan: Axel

services and products like pharmaceuticals was considered to be immoral within the German medical community.²⁷ In consideration of these limits, anti-diphtheria serum was introduced to market with leaflets containing information about the “history” and production of the serum, the evaluation and the quality of the serum, the indication, and the application of the remedy.²⁸ Furthermore, several articles of clinicians had been published in well-known medical journals like the *Deutsche Medizinische Wochenschrift* or *Berliner Klinische Wochenschrift* reporting on the use and effects of the serum, the side effects and the “best” application form, providing information to general practitioners who wanted to use the serum.²⁹

5b. Framing the Market – Supplying Producer

The supply of anti-diphtheria serum was strictly regulated. The producer had to comply with several requirements and fulfil certain qualifications. To offer a state approved remedy, the serum manufacturer had to apply to the Prussian Ministry of Cultural Affairs for permission to produce serum and to pay an “entrance fee” to finance the state-run serum institute. Another condition was the producer’s acceptance of several terms and duties: the permanent control of the live stock by a licensed veterinary; the recruitment of a medical official who was monitoring the production process and paid by the producer but responsible to the state authorities; the producer had to hire bacteriologically trained staff; every production step had to be recorded in a journal; the production plant was subjected to hygienic inspections; and every batch of serum was inspected by a centralized state-run institute. Meeting these conditions served to verify the producer’s reputation. The Ministry of Cultural Affairs would query district presidents about the company’s reputation and its pecuniary before organizing an inspection by the district veterinary and medical officials.³⁰ After an initial inspection, the serum producer was re-audited at irregular intervals.

C. Hüntelmann, Different Modes of marketing. The branding of Salvarsan (unpublished conference paper, 2010).

²⁷ Cf. Binder, Standesrecht.

²⁸ See the leaflets of the Dyestuff Industries Hoechst and the company Schering in BA Berlin, R 86/1646; GStA PK, HA 1, Rep. 76 VIII B, No. 3747; and in APEI the files on Dyestuff Industries Hoechst: dept. Vd, no. 1, vol. 1; or Schering: APEI, dept. Vd, no. 2, vol. 1.

²⁹ Articles were also published in *The Lancet*, the *British Medical Journal* and the *Semaine Médicale*.

³⁰ Cf. Otto, Staatliche Prüfung; in practice the audit of the company Schering by the councilors Adolf Schmidtman (Prussia) and Adolf Dieudonné (Imperial Health Office) in GStA PK, HA 1, Rep. 76 VIII B, No. 3748; correspondence concerning the audit procedure by Louis Merck in February 1895 in BA Berlin, R 86/1182; and the correspondance with the state of Hamburg, the Imperial Health Office and the Prussian Ministry of Cultural Affairs concerning the audit of the company Ruete & Enoch in April 1895 in BA Berlin, R 86/1646.

As mentioned above, early debates about serum regulation considered founding a state-run institute along the lines of the Pasteur Institute in Paris that would cover the total demand for anti-diphtheria serum. Another alternative involved organizing serum production like the production of small pox vaccines, in regional production plants under state surveillance. But this alternative has not even been touched upon in debates about state regulation. Apart from the discussions about the foundation of a central state institute, the Dyestuff Industries in Hoechst as well as the company Schering in Berlin had invested large sums of money in research and development and in the construction of a new Biological Department in which the serum was produced.³¹ In the discussions about the organization and regulation of serum production it was feared that private companies could resist these plans or would file for damages.³² Friedrich Althoff, head of department in the Prussian Ministry of Cultural and Medical Affairs, also assumed that competition between different private companies might have a positive impact on serum quality. And in fact, this quality became the unique characteristic of the serum.³³

Another difficult point was the federal constitution of the German Empire. Germany was a federal state and the serum producers were spread throughout the entire Empire. Although the Empire was responsible for the overall legislation, it had no executive power and it depended on the collaboration with the federal states, especially Prussia, for the law enforcement.³⁴ Taking into account that serum was produced in private companies and in different federal states (not to mention serum produced abroad), the establishment of a central control institute seemed to be the best solution for the public health administration. In fact, the Royal Prussian Institute for Serum Research and Serum Testing became an obligatory passage point: Since April 1895 only serum, tested and approved by the state-run institute entered the serum market in Germany.³⁵

³¹ The description of the Biological Department of Dyestuff Industries Hoechst in Arnold Eiermann, *Die Einrichtung zur Darstellung des Diphtherie-Heilserums in den Höchster Farbwerken*, in: *Münchener Medicinische Wochenschrift* 41 (1894), pp. 1038-1040.

³² Cf. the minutes of the meeting from 3rd and 5th of November 1894 in BA Berlin, R 86/1646.

³³ See below.

³⁴ Cf. Woelk, Wolfgang/Jörg Vögele, *Einleitung*, in: Woelk, Wolfgang/Jörg Vögele (eds.), *Geschichte der Gesundheitspolitik in Deutschland. Von der Weimarer Republik bis in die Frühgeschichte der "doppelten Staatsgründung"*, Berlin 2002, pp. 11-48.

³⁵ Or, the other way around, on the German pharmaceutical market no serum was distributed through pharmacies that had been not been tested and certified by the state-run serum institute. For the obligatory passage point see as a summary Bruno Latour, *Reassembling the Social. An Introduction to Actor-Network-Theory*, Oxford 2005; for an early definition cf. Michel Callon, *Elements of a sociology of translation. Domestication of the Scallops and the Fishermen of St Brieuc Bay*, in John Law (ed.), *Power, Action and Belief: A New Sociology of Knowledge?* London 1986, pp. 196-233; the serum institute as an obligatory passage point in accordance to Callon and Latour in Axel C. Hüntelmann, *Ways of Evaluation*.

The organisation of serum control had wide-ranging consequences for the producers. First, only serum producers complying with the strict professional, hygienic standards were allowed to produce and sell sera. For foreign serum producers it was very difficult to apply for a permission to sell serum in Germany,³⁶ and as a matter of fact they were excluded from the German market. Furthermore, due to the high “entrance fee” and the standards, small companies were likewise excluded. Smaller start-up companies tried to offer serum, but after a short while they gave up.³⁷ In contrast, the bigger industrial chemical companies built up Biological Departments like the Dyestuff Industries in Hoechst, Schering in Berlin, or E. Merck in Darmstadt.³⁸ The bigger companies, being in close contact to state and municipal authorities, were also involved in the establishment of the state regulation of the serum market. Especially Dyestuff Industries in Hoechst remained in good standing with officials in the Prussian Ministry of Cultural Affairs. The chemical companies had not only easy access to state authorities and due to their contacts a request for their reputation was obsolete. Moreover, they were in a position to negotiate the modalities of payment of the “entrance fee” while it was difficult for small companies to raise the money.³⁹ So the entrance fee was just more than a contribution to fund the state-run serum institute. It was also a barrier for newcomers to enter the serum market.

In the same way, high quality standards prevented newcomers from competing on the market. The standards set in the *Pharmacopeia Germanica* were criticised by other chemical companies in the 1880s as an obstacle to exclude competitors. They were mainly initiated by J. Holtz, director of Schering who was nominated as an expert for the permanent drug board of the Imperial Health Office that fixed the standards. At the time, Schering was for several remedies the only company that was able to produce the chemicals at the fixed

Therapeutic Agents between Standardization and Institutionalization, in: Gaudillière/Hess (eds.), *Ways of Regulating*, pp. 65-76.

³⁶ Cf. the complicated correspondence with the Swiss company Haeffliger & Cie. in Bern that was kept via the Swiss-German embassy and the Foreign Ministry in APEI, dept. Vd, no. 5, vol. 1 and BA Berlin, R 86/1646. At the end, the company lost interest in the German market.

³⁷ Cf. the company Müller & Pröscher in Hoechst, who produced anti-diphtheria serum around 1901/1902. When they received the notification to pay the “entrance fee”, Proeschler left the company, probably because of the financial burden, cf. APEI, dept. Vd, no. 6, vol. 1.

³⁸ Axel C. Hüntelmann, *Two Cultures of Regulation. The Production and State Control of Diphtheria serum at the End of the Nineteenth Century in France and Germany*, *Hygiea Internationalis* 6 (2007), no. 2, pp. 99-119; see also the company festschrift of Dyestuff Industries Hoechst of 1913.

³⁹ In my opinion, we have to assess the state-request for the financial situation of the companies in this context.

high grade of purity.⁴⁰ Purity and quality also gave producers who were able to enter the market a competitive edge. Even though it was possible for a life scientist trained in bacteriological techniques to produce serum, it was difficult to satisfy the required high quality and purity, the fixed minimum of immunization units, and comply with regulations. The tacit knowledge of their staff members and scientists, attained over several years, gave the dominating companies a head start that was difficult to catch up.⁴¹ Established firms knew how to breed the best bacteria cultures, how to filter the strongest toxins, how to decrease the period of intoxication and immunisation, and how to increase the amount of immunisation units per blood-letting – that made the serum more valuable.⁴² To comply with regulations, firms needed to invest into administrative techniques and organizational knowledge. These brought with them increased overhead costs, which in turn could be covered more easily by bigger companies.

5c. Framing the Market – Product and Price

Besides the producer and the consumer, the institutionalized regulation of serum influenced both the product itself and its price. Ultimately, the pricing of anti-diphtheria serum was anything but market driven. Life-saving pharmaceuticals like anti-diphtheria serum had a relatively inelastic price as ill persons – the consumers – depended on it. The prospect of high profits derived from the serum's inelastic price was the main reason that public health authorities fixed a maximum price for the serum. Even the discount rates for hospitals and social welfare institutions were fixed. On the other hand, the cost structure was nearly the same in all production plants, determined by expenses for horses, food, maintenance, staff and testing fees. Furthermore, the packaging and product design were also regulated by the state.⁴³ As Prussian officials intended, market advantages could be derived only by improving the product.

The most effective means of thwarting competitors was the enhancement of the serum's potency. The increasing effectiveness of the serum had several effects and advantages for the serum producer. First, the producer could distinguish himself from competitors by highlighting the quality of his serum – guar-

⁴⁰ The relation between lobbying and quality standards is mentioned in Erika Hickel, *Das Kaiserliche Gesundheitsamt und die chemische Industrie im Zweiten Kaiserreich (1871-1914): Partner oder Kontrahenten?* In: Mann, Gunter/Rolf Winau (eds.), *Medizin, Naturwissenschaft, Technik und das Zweite Kaiserreich*, Göttingen 1977, pp. 64-86; and in the context of the 5th *Pharmacopeia* in 1910 Jürgen Holsten, *Das Kaiserliche Gesundheitsamt und die Pharmazie. Dargestellt an der Entstehung des Deutschen Arzneibuches, fünfte Ausgabe*, Diss. med., Free University, Berlin 1977.

⁴¹ Cf. Michael Polanyi, *The Tacit Dimension*, London 1966.

⁴² In a double sense: serum with a higher value of immunisation units was sold for a higher price because the price is determined by the immunisation units.

⁴³ Cf. Throm, *Diphtherieserum*.

anted and certified by the state-run serum instituted. State approved serum was treated like a trademark and seen as a “guarantee” of high quality. Abroad, German serum and the German system of serum approval became synonymous for high quality. In Germany it was more difficult to distinguish one’s own serum from the products of competitors.

I will demonstrate the importance of quality as a distinctive feature by using the example of veterinary serum. While the state approval of human serum was mandatory, the evaluation of veterinary serum was voluntary. The market for veterinary sera was more diverse, as besides the big chemical companies agricultural cooperatives also started to produce veterinary sera. Furthermore, the quality standards were less strict due to fact that only animals were affected. Nevertheless, some serum producers – for instance Dyestuff Industries Hoechst – proposed mandatory serum testing for some veterinary sera – despite the higher expenses. The argument of the companies proposing mandatory testing was that high quality standards had to be maintained. As mentioned, serum testing was used as a means to exclude newcomers from the market. When the course was set for the approval of veterinary sera to become mandatory around 1910, the market impact of rising quality standards, “entrance fees”, and the regular testing fees became a topic of considerable dispute.⁴⁴

The state-tested quality of veterinary serum had a further economic implication. Before the mandatory test of red murrain sera had been established, producers of this serum (a remedy against an animal disease with a high mortality rate that effected livestock, especially pigs) offered compensation for any animal that died after or despite a preventive immunization. This was done to strengthen confidence in red murrain serum and its use. But after several years, when the method and value of immunization against red murrain was allegedly “undoubtedly clear” and “safe” and the “impeccable quality” of the state-approved serum seemed guaranteed, the compensation promise was taken back.⁴⁵ The state’s seal of approval – which of course rested on negotiated standards and scientific expertise which is necessarily limited – made the product immune against criticism, as it implied that the death of an animal must have been caused by local or individual factors, but not by the ineffectiveness of the serum.

A high number of immunization units of a certain serum was regarded as the most important sign for high quality. The link between high quality and immunization unit resulted from the fact that the probability that the human body showed an allergic reaction against the animal protein content of the serum (albumin) increased with the amount of serum being injected. The more effective the serum was, the lesser the quantity that had to be injected. The subcuta-

⁴⁴ Cf. files for red murrain serum in APEI, dept. IX, no. 1, vol. 1.

⁴⁵ Cf. the announcement of the Farbwerke Hoechst in December 1908, APEI, dept. IX, no. 1, vol. 1.

neous injection of five centilitres causes less pain or at least discomfort than ten centilitres. A lower quantity of serum also reduced the probability of idiosyncratic reactions, for instance emphysema. Overall, using less serum was better for the patient, it aided advertising – and also helped the producer.

Increasing the potency of the serum also reduced the testing fees for the producer. As mentioned, a sample of each batch of anti-diphtheria serum produced was sent to the institute for serum testing. As the institute charged the producer according to the serum batch and the amount of serum produced, companies could reduce the fees and cut costs by producing less, but more effective serum. Rarely were reduced costs passed on to the consumer as price cuts, and so producers reaped the savings as additional profits. Finally, serum producers improved the packaging, for instance the company Merck used rubber plugs instead of cork to seal the phials. Naturally, such improvements – once introduced onto the market – became obligatory for all producers.⁴⁶ Such strategies indicate that quality was the main battleground on which producers competed for market share.

Investing into the quality of remedies was all the more important as an economic strategy as other ways of marketing biologicals was a delicate undertaking. Critics of the new serum therapy (especially members of anti-vaccination campaigns) as well as medical professionals expressed their discontent with the marketing and branding of pharmaceuticals. Generally, advertisements of pharmaceuticals in newspapers were frowned upon by orthodox medicine and press campaigns were judged to be dubious and in violation of altruistic and ethical norms.⁴⁷ Critics decried the nexus between science and economics. Paul Ehrlich for instance, who was involved in the development of anti-diphtheria serum and contracted to the Dyestuff Industries Hoechst, had to cancel all current contracts with the chemical industry before he could become director of the new Serological Institute.⁴⁸ Hence, “serious” marketing for the chemical industry involved publishing scientific articles in professional medical journals about clinical trials, product improvements, or technical and institutional changes.⁴⁹

⁴⁶ Cf. the correspondence with the company Merck and the Imperial Health Office and, after the installation of rubber plugs had been proved successful, the circular of the Imperial Health Office and the decree that prescribed the use of rubber plugs for phials in BA Berlin, R 86/1646.

⁴⁷ While German health professionals were very dubious about marketing and the promotion of remedies, this was different in Great Britain and the US. Cf. for the official proscription of medical advertisements (and the efforts to occur this ban) Binder, *Standesrecht*.

⁴⁸ Cf. Axel C. Hüntelmann, Paul Ehrlich 1854-1915. *Leben, Forschung, Ökonomien*, Netzwerke, Göttingen 2011, pp. 102-110.

⁴⁹ Cf. Hüntelmann, *Branding Salvarsan*.

6. Future Prospects

Anti-diphtheria serum was one of several remedies produced in an industrial style that were opening a new marketplace. Indeed, anti-diphtheria serum was a landmark in the evolving market of biologicals. The systematic development of anti-diphtheria serum – test series in vitro and in vivo, clinical trials, the monitoring of the practical use of serum – became a blueprint for the research and development of further pharmaceuticals. Despite all the restrictions and price regulations, the evolving chemical and pharmaceutical industry earned huge profits by producing anti-diphtheria and other serum: the construction costs for the production plant of the Biological Department of the Dyestuff Industries in Hoechst, built during 1894, had already been amortized by the end of that year and within the following twelve months the department had made a profit of 707,000 Marks.⁵⁰ After the anti-diphtheria serum was introduced to the market, several other sera, vaccines and biological diagnostics like tuberculin followed.⁵¹ All human vaccines and sera were either produced in state-run institutes⁵² or were centrally controlled by the serum institute.⁵³ Admittedly, other veterinary sera were sold on the free market, but several sera were also placed under voluntary (and later mandatory) state control. Furthermore, in the 1920s, chemotherapeutics like Salvarsan were centrally tested in accordance to the model of serum control in state-run institutes. The formation of the market for anti-diphtheria serum was not a one-off phenomenon – it was a blueprint for prospective pharmaceuticals.

7. Evolving the Market Field

The formation of the marketplace for biologicals was embedded in social, economic, political, and scientific frameworks.⁵⁴ The market depended on biopower and indirect government, capitalism and free market system, the federal constitution of the German Empire, the scientific developments in bacteriology and the pharmaceutical industry, and past experiences with the tuberculin scandal.

Given the complexity of this marketplace, we must take the aims and motives of different actors into account: in an existential situation, the consumer

⁵⁰ Laubenheimer pointed out that the building costs for the production plant of 444,000 Marks were written off with the profit of the first year, cf. Laubenheimer, *Geschichte*, p. 10; Throm, *Diphterierserum*, table.

⁵¹ Cf. Otto, *Staatliche Prüfung*, and later editions.

⁵² Rabies and typhoid vaccines were produced in the Institute for Infectious Diseases in Berlin, small pox vaccines were produced in regional institutes.

⁵³ Along the lines of the German model, several other state-run institutes had been established abroad.

⁵⁴ Cf. Fligstein, *Architecture*; Beckert, *Ordnung*, p. 45.

(patients and physician alike) sought a remedy for a severe disease. The producer wanted to make a profit – not at any price, but recognizing that an effective remedy is its best promotion and that an ineffective or harmful remedy might ruin the company. The state had a fundamental interest in combating infectious diseases for biopolitical reasons and to demonstrate his capacity to act. The state therefore insisted upon pure and effective anti-diphtheria serum in the required quantities. Supplying people with anti-diphtheria serum was a major public health issue and the state had both to ensure the supply of anti-diphtheria serum and to minimize any related public health risks, because no one had many experiences in dealing with biologicals.

Due to the cooperation between the Empire, industry, and the federal states there was an indirect type of governance. In the German Empire, the serum was produced by private pharmaceutical companies, but the state regulated the price and exercised control over the production process to ensure a pure and effective serum. Nevertheless, the system of quality control was not imposed by the state: it was worked out in cooperation with scientists, state-run institutes, the federal states, and the pharmaceutical industry.⁵⁵

By regulating the biopolitical objects to combat infectious diseases with pharmaceuticals, the state had to consider the federal constitution and economic order of a free market system. The development of serum therapy coincides with the formation of a pharmaceutical industry (or better put: its divergence from the chemical industry) that from the outset invested huge sums of money in serum therapy. Nevertheless, after anti-diphtheria serum came onto market, the state took over an indirect control. Central government and the federal states had to cooperate with the industry to guarantee the success of the control measures and it was certainly in the companies' own interest to cooperate with the state. Thus, we can say that the control exercised by the serological institute was necessary to supervise serum production throughout the empire. The state-run serological institute became an obligatory passage point for the anti-diphtheria serum that was sold on the German pharmaceutical market. Overall, regulation of the anti-diphtheria serum (and other sera) and the implementation of a state-run institute for quality control can also be interpreted in

⁵⁵ Cf. for the triangle of state, science, industry in the German Empire for instance Margit Szöllösi-Janze, *Der Wissenschaftler als Experte. Kooperationsverhältnisse von Staat, Militär, Wirtschaft und Wissenschaft, 1914-1933*, in: Doris Kaufmann (ed.), *Geschichte der Kaiser-Wilhelm-Gesellschaft im Nationalsozialismus. Bestandsaufnahme und Perspektiven der Forschung*, Göttingen 2000, pp. 50-58; idem, *Die institutionelle Umgestaltung der Wissenschaftslandschaft im Übergang vom späten Kaiserreich zur Weimarer Republik*, in: Rüdiger vom Bruch/Brigitte Kaderas (eds.), *Wissenschaften und Wissenschaftspolitik. Bestandsaufnahmen zu Formationen, Brüchen und Kontinuitäten im Deutschland des 20. Jahrhunderts*, Stuttgart 2002, pp. 60-74; idem, *Wissensgesellschaft in Deutschland. Überlegungen zur Neubestimmung der deutschen Zeitgeschichte über Verwissenschaftlichungsprozesse*, in: *Geschichte und Gesellschaft* 30 (2004) pp. 277-313.

terms of a technology of trust.⁵⁶ For the companies, the “state approved” stamp affected their marketing, guaranteeing a high quality product and effectively functioning like a trademark. Finally, the early state regulation of biologicals like serum and vaccines framed the entire serum market, and indeed constituted and framed the market as such, as it structured the product as well as the producer, the distribution of the serum and the consumer. Nevertheless, within the architecture of the market, the trade of serum was free and the different serum producers had to compete with each other. The mode of indirect government took into account the liberal capitalistic market order and made possible the free play of the forces of supply and demand.

References

- Anderson, Stuart. 2005. *Making Medicine. A Brief History of Pharmacy and Pharmaceuticals*. London.
- Balz, Viola, Alexander von Schwerin et al., eds. 2008. *Precarious Matters/Prekäre Stoffe. The History of Dangerous and Endangered Substances in the 19th and 20th century* (Preprint of the Max-Planck-Institute for the History of Science 356). Berlin.
- Beckert, Jens. 2007. Die soziale Ordnung von Märkten. In *Märkte als soziale Strukturen*, ed. Jens Beckert et al., 43-62. Frankfurt/Main.
- Bethard, Wayne. 2004. *Lotions, Potions, and Deadly Elixirs. Frontier Medicine in America*. Lanham.
- Binder, Jochen. 2000. *Zwischen Standesrecht und Marktwirtschaft. Ärztliche Werbung zu Beginn des 20. Jahrhunderts im deutsch-englischen Vergleich*. Frankfurt/Main.
- Callon, Michel. 1986. Elements of a Sociology of Translation. Domestication of the Scallops and the Fishermen of St Brieuc Bay. In *Power, Action and Belief: A New Sociology of Knowledge?*, ed. John Law, 196-233. London.
- Ernst, Elmar. 1975. *Das “industrielle” Geheimmittel und seine Werbung. Arzneifertigwaren in der zweiten Hälfte des 19. Jahrhunderts in Deutschland*. Würzburg.
- Fligstein, Neil. 2001. *The Architecture of Markets. An Economic Sociology of Twentieth-First-Century Capitalist Societies*. Princeton.
- Gaudillière, Jean-Paul. 2005. Introduction. Drug Trajectories. *Studies in the History and Philosophy of Biology and Biomedical Sciences* 36: 603-611.
- Gaudillière, Jean-Paul, and Volker Hess, eds. 2008. *Ways of Regulating. Therapeutic Agents between Plants, Shops, and Consulting Rooms* (Preprint of the Max-Planck-Institute for the History of Science 363). Berlin.
- Gradmann, Christoph. 2005. *Krankheit im Labor. Robert Koch und die medizinische Bakteriologie*. Göttingen 2005.

⁵⁶ Cf. Theodore Porter, *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life*, Princeton, 1995.

- Gradmann, Christoph. 1999. Ein Fehlschlag und seine Folgen. Robert Kochs Tuberkulin und die Gründung des Instituts für Infektionskrankheiten in Berlin 1891. In *Strategien der Kausalität. Konzepte der Krankheitsverursachung im 19. und 20. Jahrhundert*, ed. Christoph Gradmann and Thomas Schlich, 29-52. Pfaffenweiler.
- Hickel, Erika. 2008. *Die Arzneimittel in der Geschichte. Trost und Täuschung, Heil und Handelsware*. Nordhausen.
- Hickel, Erika. 1977. Das Kaiserliche Gesundheitsamt und die chemische Industrie im Zweiten Kaiserreich (1871-1914): Partner oder Kontrahenten? In *Medizin, Naturwissenschaft, Technik und das Zweite Kaiserreich*, ed. Gunter Mann and Rolf Winau, 64-86. Göttingen.
- Hickel, Erika. 1973. *Arzneimittel-Standardisierung im 19. Jahrhundert in den Pharmakopöen Deutschlands, Frankreichs, Großbritanniens und der Vereinigten Staaten von Amerika*. Darmstadt.
- Holsten, Jürgen. 1977. *Das Kaiserliche Gesundheitsamt und die Pharmazie. Dargestellt an der Entstehung des Deutschen Arzneibuches*, 5th ed., Diss. med., Free University. Berlin.
- Huerkamp, Claudia. 1985. *Der Aufstieg der Ärzte im 19. Jahrhundert. Vom gelehrten Stand zum professionellen Experten: Das Beispiel Preußens*. Göttingen.
- Hüntelmann, Axel C. 2011. *Paul Ehrlich 1854-1915. Leben, Forschung, Ökonomien, Netzwerke*. Göttingen.
- Hüntelmann, Axel C. 2010. Eigenartige Sonderstellung in der Welt. Das Königlich Preußische Institut für Experimentelle Therapie und das Georg Speyer-Haus im Deutschen Kaiserreich. In *Jenseits von Humboldt. Wissenschaft im Staat, 1850-1990*, ed. Axel C. Hüntelmann and Michael C. Schneider, 189-215. Frankfurt/Main.
- Hüntelmann, Axel C. 2008. *Hygiene im Namen des Staates. Das Reichsgesundheitsamt 1876-1933*. Göttingen.
- Hüntelmann, Axel C. 2008. The dynamics of "Wertbestimmung." *Science in Context* 21: 229-252.
- Hüntelmann, Axel C. 2008. Ways of Evaluation. Therapeutic Agents between Standardization and Institutionalization. In *Ways of Regulating. Therapeutic Agents between Plants, Shops, and Consulting Rooms*, ed. Jean-Paul Gaudillière and Volker Hess, 65-76. (Preprint of the Max-Planck-Institute for the History of Science 363). Berlin.
- Hüntelmann, Axel C. 2007. Two Cultures of Regulation. The Production and State Control of Diphtheria serum at the End of the Nineteenth Century in France and Germany. *Hygiea Internationalis* 6 (2): 99-119.
- Latour, Bruno. 2005. *Reassembling the Social. An Introduction to Actor-Network-Theroy*. Oxford.
- Loetz, Francisca. 1994. "Medikalisierung" in Frankreich, Großbritannien und Deutschland, 1750-1850. Ansätze, Ergebnisse und Perspektiven der Forschung. In *Das europäische Gesundheitssystem. Gemeinsamkeiten und Unterschiede in historischer Perspektive*, ed. Wolfgang E. Eckart and Robert Jütte, 123-161. Stuttgart.
- Loetz, Francisca. 1993. *Vom Kranken zum Patienten. "Medikalisierung" und medizinische Vergesellschaftung am Beispiel Badens 1750-1850*. Stuttgart.

- Mochmann, Hanspeter, and Werner Köhler. 1984. *Meilensteine der Bakteriologie. Von Entdeckungen und Entdeckern aus den Gründerjahren der Medizinischen Mikrobiologie*. Jena.
- Müller-Jahncke, Wolf-Dieter, Christoph Friedrich et al. 2005. *Arzneimittelgeschichte*, 2nd ed. Stuttgart.
- Persson, Ann S. 2009. *Smallpox, Syphilis and Salvation. Medical Breakthroughs that changed the World*. Wollombi.
- Polanyi, Michael. 1966. *The Tacit Dimension*. London.
- Porter, Theodore. 1995. *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life*. Princeton.
- Quirke, Viviane, and Judy Slinn, eds. 2010. *Perspectives on 20th-century pharmaceuticals*. Frankfurt/Main.
- Schneider, Wolfgang. 1969. *Geheimmittel und Spezialitäten. Sachwörterbuch zu ihrer Geschichte bis um 1900* (Lexikon zur Arzneimittelgeschichte 4). Frankfurt/Main.
- Schott, Heinz. ed. 2006. *Meilensteine der Medizin*. Dortmund.
- Seckelmann, Margrit. 2006. *Industrialisierung, Internationalisierung und Patentrecht im Deutschen Reich, 1871-1914*. Frankfurt/Main.
- Szöllösi-Janze, Margit. 2004. Wissensgesellschaft in Deutschland. Überlegungen zur Neubestimmung der deutschen Zeitgeschichte über Verwissenschaftlichungsprozesse. *Geschichte und Gesellschaft* 30: 277-313.
- Szöllösi-Janze, Margit. 2002. Die institutionelle Umgestaltung der Wissenschaftslandschaft im Übergang vom späten Kaiserreich zur Weimarer Republik. In *Wissenschaften und Wissenschaftspolitik. Bestandsaufnahmen zu Formationen, Brüchen und Kontinuitäten im Deutschland des 20. Jahrhunderts*, ed. Rüdiger vom Bruch and Brigitte Kaderas, 60-74. Stuttgart.
- Szöllösi-Janze, Margit. 2000. Der Wissenschaftler als Experte. Kooperationsverhältnisse von Staat, Militär, Wirtschaft und Wissenschaft, 1914-1933. In *Geschichte der Kaiser-Wilhelm-Gesellschaft im Nationalsozialismus. Bestandsaufnahme und Perspektiven der Forschung*, ed. Doris Kaufmann, 50-58. Göttingen.
- Throm, Carola. 1995. *Das Diphtherieserum. Ein neues Therapieprinzip, seine Entwicklung und Markteinführung*. Darmstadt.
- Ueyama, Takahiro. 2010. *Health in the marketplace. Professionalism, therapeutic desires, and medical commodification in late-Victorian London*. Palo Alto.
- Wimmer, Wolfgang. 1994. "Wir haben fast immer was Neues". *Gesundheitswesen und Innovation der Pharma-Industrie in Deutschland, 1880-1935*. Berlin.
- Woelk, Wolfgang, and Jörg Vögele, eds. 2002. Einleitung. In *Geschichte der Gesundheitspolitik in Deutschland. Von der Weimarer Republik bis in die Frühgeschichte der "doppelten Staatsgründung"*, 11-48. Berlin.